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PROPERTIES OF SOIL UNDER ASPEN AND HERB-SHRUB COVER

Ronald K. Tew[1]

ABSTRACT

Several physical and chemical soil properties were measured and related to site aspect and vegetation type. Soil texture, aggregation, organic matter content, nitrate production, and moisture-holding characteristics varied between aspects. Soils under aspen stands have higher organic matter content, with accompanying higher moisture-holding capacity, than do soils on adjacent herb-shrub sites.

The physical and chemical properties of soils are partially determined by the vegetation they support; conversely, the type and amount of vegetation depend on the soil productivity. The exact nature of these relations has not been clarified on most wildland soils, but there is great need for such information as a basis for management decisions.

Changes in soil characteristics are apt to occur when water yield improvement measures are applied to our mountain lands, especially when such measures include the manipulation of vegetation. The influence of these changes on soil stability, productivity, and water-holding characteristics becomes of utmost interest. Several differences between soils under aspen and on adjacent sites covered with herbs and shrubs, on each of four aspects, have been evaluated. They show possible soil changes that might be expected if a type conversion were attempted.

METHODS

Soil samples were collected in the vicinity of Logan Canyon in northern Utah. Only the surface 6 inches was sampled, as this is the zone of major biological activity and would be most influenced by management practices. Also, the vegetation occupying the site would be most influential in modifying soil properties in this zone. Paired soil samples (one from aspen, the other from adjacent herb-shrub cover) were collected from 48 random locations ranging in elevation from 6,500 to 8,500 feet. Twelve pairs of

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[1] Associate Plant Physiologist, stationed in Logan, Utah, at the Forestry Sciences Laboratory, which is maintained in cooperation with Utah State University.

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samples were obtained on each aspect--north, south, east, and west--making a total of 96 samples. Each sample was a composite of four subsamples. All soils were taken to the laboratory, passed through a 2-mm. sieve, and analyzed.

Texture and aggregation were determined by hydrometer methods. An acid neutralization technique was used for the lime determinations, and organic matter was determined by a chromic acid oxidation procedure. Moisture relations were evaluated with a pressure membrane apparatus. Available phosphorus was extracted from the soil with a 0.5N sodium bicarbonate solution and measured colorimetrically. The pH was measured on a Beckman Model 12 pH meter[2] using a saturated soil paste. The nitrogen-supplying capacity was evaluated by measuring the amount of nitrate produced in a moist 10-gram soil sample during a 2-week incubation period at 35°C.

RESULTS

All aspen sites sampled had a mature stand of vigorous trees averaging between 5 and 6 inches in diameter. The herb-shrub sites were occupied by big sagebrush (*Artemisia tridentata* Nutt.), rabbitbrush (*Chrysothamnus nauseosus* (Pall.) Britt.), snowberry (*Symphoricarpos vaccinoides* Rydb.), yarrow (*Achillea lanulosa* Nutt.), horsemint (*Agastache urticifolia* (Benth.) Kuntze), tall butterweed (*Senecio serra* Hook.), and several grass species. On all sites similar species were present, but there were variations in cover density and percentage composition. Table 1 provides a summary of the measured soil properties, each value representing an average of 12 samples.

Texture and aggregation.--The majority of the soils tested were loams. Silt content was similar on all aspects and vegetation types. Aspen sites were higher in sand and lower in clay than the adjacent herb-shrub sites. South aspects were lowest in clay and highest in sand. These variations in texture were reflected in the quantity of water-stable aggregates present.

Aggregation was lowest on south aspects regardless of vegetation type. This property was found to be directly related to the clay and organic matter content. An equation was developed to correlate the various soil properties, as follows:

$$Y = 11.64 + 1.692X_1 - 0.0036X_1^2 + 0.649X_2$$

where Y is the percent aggregation, X_1 represents the percent clay, and X_2 the percent organic matter.

A multiple correlation coefficient of 0.88 indicated that a good relation existed. This equation would apply only under the conditions tested, however.

No significant difference in aggregation was observed between vegetation types. Soil under aspen contained more organic matter but less clay, so that the factors affecting aggregation were balanced.

Lime content and pH.--In general, pH was greater on aspen sites than on adjacent herb-shrub sites. The difference was usually from 0.1 to 0.2 pH unit. The range in pH for all samples was from 5.8 to 6.8, and most were near 6.2. A greater range in pH would have been expected if subsoils had also been sampled.

The calcium carbonate equivalent (or lime) in these soils was closely related to pH. Aspen sites had slightly greater lime content than adjacent sites. Differences due to aspect were insignificant. Differences in both pH and lime content were statistically significant at the 5-percent level.

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[2] Trade names are used herein for identification and do not imply endorsement by U.S.D.A. Forest Service.

Table 1.--Summary of soil properties

Vegetation type;aspect	Sand	Silt	Clay	Aggreg.	Organic matter	Lime	1/3 atm.	15 atm.	Avail. H_2O	Particle density	Available phosphorus[1]	Ppm[2] NO_3	pH
							-Percent-						
Aspen:													
North	37.1	42.7	20.2	55.7	10.6	1.62	33.9	16.5	17.4	2.49	260	33.9	6.16
South	43.2	41.0	15.8	42.4	10.2	1.43	30.2	13.3	16.9	2.49	258	64.9	6.32
East	37.7	41.2	21.1	54.1	12.3	1.77	35.8	17.4	18.4	2.47	267	45.9	6.24
West	34.7	43.4	21.9	58.9	10.3	1.49	33.6	16.1	17.5	2.49	265	42.6	6.17
Average	38.1	42.1	19.8	52.8	10.9	1.58	33.4	15.8	17.6	2.49	263	46.8	6.22
Herb-shrub:													
North	31.6	43.9	24.5	55.4	7.7	1.32	29.9	13.6	16.3	2.53	219	60.4	6.06
South	41.3	40.9	17.8	42.0	6.5	0.98	24.0	9.8	14.2	2.53	212	56.0	6.11
East	31.5	42.1	26.4	55.8	6.6	1.40	29.4	13.9	15.5	2.54	207	58.7	6.09
West	32.1	43.3	24.6	50.9	7.3	1.38	28.9	14.2	14.7	2.54	207	55.5	6.14
Average	34.1	42.6	23.3	51.0	7.0	1.27	28.1	12.9	15.2	2.54	211	57.7	6.10

[1] Expressed in pounds of P_2O_5 per acre 6 inches.
[2] As produced in moist soil samples incubated 2 weeks at 35°C.

Organic matter content.--A large difference was observed between vegetation types, aspen sites having approximately 4 percent more organic matter. South aspect sites had slightly less organic matter than the other aspects tested. The importance of these differences becomes evident when other physical and chemical properties of the soil are considered.

Particle density.--Equations were developed for both vegetation types to relate particle density of the soil to the organic matter content. It was assumed that parent material was similar, as the same Y intercept was found for both vegetation types; therefore, all data were combined into a single equation:

$$Y = 2.63 - 0.0134X$$

where Y is particle density and X is orgnanic matter content.

A correlation coefficient of 0.88 indicated that a good relation existed. Estimates of either particle density or organic matter content could be obtained from such an equation if the concomitant variable were known. Particle density estimates would be useful when porosity determinations are desired.

1/3-and 15-atmosphere percentages.--Close relations existed between the moisture measurements and the amount of clay and organic matter present. A multiple regression analysis using these two factors and either 1/3- or 15-atmosphere percentages as the dependent variable gave correlation coefficients of 0.866 for the 1/3- and 0.929 for the 15-atmosphere percentages. The difference between 1/3- and 15-atmosphere percentages is an estimate of available moisture for the appropriate horizon. On all aspects, the 1/3- and 15-atmosphere percentages were higher on aspen sites than on adjacent areas. Although 1/3-atmosphere percentages were approximately 5 percent higher on aspen sites, the 15-atmosphere percentages were also higher, so that differences in available moisture between vegetation types were only 2 to 3 percent. South aspects had 1 to 2 percent less available moisture than the other aspects.

Fertility status.--No single soil property measured could be directly related to the rate of nitrification. Nitrate production was generally highest on the herb-shrub sites, all aspects being similar. Aspen sites were more variable; nitrate production was highest on south aspects and lowest on north aspects.

Phosphorus availability was greater on aspen sites than on adjacent areas for all aspects. No difference was noted between aspects on either vegetation type.

DISCUSSION

Many soil properties were different under aspen and adjacent vegetation types, at least in the surface 6 inches. These soil differences were probably related to the vegetation type, since climate and topography were similar on paired sites. Also, particle densities were identical under the two vegetation types when compared on an organic-matter-free basis; therefore, the soils were apparently developed from the same parent material. The differences observed in the soil properties under the two vegetation types are corroborated by McKeague and Bentley (1960), who found that aspen leaves altered redox potentials, which in turn influenced soil development.[3]

Although texture was not equivalent on the two vegetation types, the differences were probably small enough to ignore in regard to the initial establishment of aspen on any particular site. The fact that aspen was growing on soils covering a wide range in texture seems to justify this conclusion.

If aspen were removed, we could expect a decrease in the organic matter content of the soil. Decreases in moisture-holding capacity, aggregation, and porosity would probably follow the organic matter reduction. Phosphorus availability might also decline.

Results from the pH and lime determinations indicate cycling of bases has been more active under aspen than on adjacent sites. This is important in control of the quantity of nutrients available. As indicated by the levels of nitrification resulting from laboratory tests, several plants would probably show a significant response to nitrogen applications on both vegetation types if moisture was not a limiting factor. All sites appeared to be high in available phosphorus, but additional information relating plant response to experimental results would be desirable before any conclusions were made about phosphorus responses. Until such information is obtained, the differences observed between vegetation types serve only for comparison.

Aspect as well as vegetation type is important in determining soil quality. Aggregation and moisture-holding properties were poorest on south aspects, where soils were coarse textured. Lime content, pH, particle density, and phosphorus availability were similar on all sites. Results indicate that aspect is important from the standpoint of species adaptability and water-holding capabilities. Soils having poor aggregation, such as on the south aspects, would be more unstable and susceptible to erosion and would require more careful management than soils on other aspects.

Removal of aspen and its replacement with another vegetation type will probably cause some changes in the underlying soil. The cited soil differences existing between established aspen sites and adjacent herb-shrub sites point up some of the probable long-term changes to be expected if aspen were converted. Some changes may occur in a few years; others may require decades or even a century.

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[3] McKeague, J. A., and C. F. Bentley. The effect of drainage condition on the redox potential, leachate composition and morphological characteristics of a soil parent material studied in the laboratory. Can. J. Soil Sci. 40(2): 121-129. 1960.